REPORT

OF

SPECIAL

COMMITTEE ON SEWERAGE

FOR

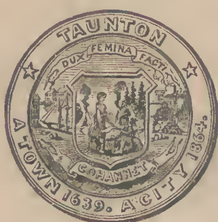
CITY OF TAUNTON,

WITH

REPORT AND PROPOSED PLAN

BY

J. HERBERT SHEDD, C. E.



TAUNTON:
PRINTED AT THE OFFICE OF C. A. HACK & SON,
1878.

Taunton, Mass., Special Committee on Sewerage

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CITY OF TAUNTON.

IN BOARD OF ALDERMEN, April 18, 1877.

PETITION of Wm. H. Fox and others, for the appointment of a Special Committee to consider and report a system of Sewerage for the City, with plans and estimates of cost of the same, was referred to a Special Committee to consist of one Alderman and as many as the Common Council may join.

Committee appointed,—Alderman BENT,—Councilmen JACKSON and RHODES.

A true transcript of the Record.

Attest,

J. M. CUSHMAN, City Clerk.

PETITION.

TO THE HONORABLE THE MAYOR, ALDERMEN AND COMMON COUNCIL OF THE CITY OF TAUNTON;

The undersigned, citizens and taxpayers of Taunton, respectfully represent, that the city is greatly deficient in the proper means of drainage, both as regards the carrying off of surface water and the waste from domestic and manufacturing operations;—that in consequence of this deficiency much inconvenience and danger to health exists, and expensive repairs of streets and highways are annually necessary.

Therefore, your petitioners, believing that the interests of the city require it, request that the subject of sewerage be made a matter of thorough investigation by a special committee to be appointed at as

early a day as practicable, who shall be instructed to present a complete and accurate report on the subject, accompanied by plans for sewering the city, with estimates of cost of doing the same.

Signers.

Wm. H. Fox,	E. U. Jones,
Wm. Mason,	Silas D. Presbrey,
Edmund H. Bennett,	Geo. W. Barrows,
Ezra Davol,	Jos. Murphy,
Charles Foster,	Wm. B. Sproat,
A. J. Barker,	Nomus Page,
Edgar H. Reed,	Wm. C. Lovering,
N. H. Skinner,	Charles Curtis,
C. R. Vickery,	S. P. Hubbard,
C. R. Atwood,	E. J. Bassett,
Henry G. Reed,	A. S. Deane,
J. W. Hayward,	C. T. Hubbard.

CITY OF TAUNTON.

IN BOARD OF ALDERMEN, Jan. 23, 1878.

ORDERED, That a Joint Special Committee be appointed, to consist of two Councilmen, and as many as the Board of Aldermen may join thereto, to report upon the subject of Sewerage.

Received from the Common Council and adopted in concurrence.

Alderman BENT, and Councilmen RHODES and TINKHAM appointed.

A true copy. Attest,

J. M. CUSHMAN, City Clerk.

To the Honorable City Council:

The Joint Special Committee, appointed under the foregoing order, respectfully submit the following

REPORT:

The future welfare of our city depends upon a wise and efficient treatment of questions of so serious a nature as that proposed in the petition under which your committee were appointed.

It is the imperative duty of every municipality to provide and maintain all the safeguards within its power for the preservation of the health and morals of its people. On the other hand, it is equally imperative that there shall be no waste or injudicious use of the public funds or credit.

Neglect of the former duty will inflict manifold ills upon its citizens in bodily suffering, sorrow, and pecuniary distress and surely result in the decline of the prosperity of the city; while a disregard of the latter will bring dishonor, discredit and burden of debt. Both carry the penalty of increased taxation.

Undoubtedly either of these faults may occur through indifference to a sense of duty, ignorance, error in judgment, or hasty, inconsiderate action, on the part of public officers, whose intentions are honest and whose management of other affairs may be above all criticism.

Fully appreciating the importance of the work and the responsibility of their position, your committee determined to use all available means to avoid, if possible, these dangers. Public sentiment was aroused to the necessity of an investigation; indifference to the health and comfort of the people must give way to vigilance and decided action; there must be thorough information on the subject, lest ignorance beget failure; careful study and thought must prevent error in judgment, and time must be taken for deliberation, lest hasty conclusions should lead to unwise or improvident expenditures.

Your committee, after a careful consideration of the duty expected of them, were convinced that the importance of the work demanded the services of an experienced, skillful Engineer, thoroughly versed in the subject of sewerage, whose opinion would carry weight with it.

Upon diligent inquiry, they became assured that Mr. J. Herbert Shedd, of Providence, was eminently fitted for the work. His careful study of the subject and long practical experience, added to his ability as an Engineer, have won for him such a reputation that he is counted one of the best authorities on sewerage. The committee felt that he could recommend a plan, which would be excellent both in theory and practice, and which our city would be safe in adopting.

Accordingly Mr. Shedd was engaged to furnish a plan and report, of a general system of sewerage for the populated portion of the city. To that end, he made a thorough, personal examination of the topography of

our city and its surroundings, directed the surveys necessary to be made, obtained what information he could of our present sewers and methods of drainage, and procured such statistics of population and industries, as would be of service to him in a study of the question involved. He held frequent consultations with the committee and various plans were discussed and abandoned. As the investigation proceeded, the general features of the proposed scheme forced themselves upon our conviction, until it developed into a complete system, which we were satisfied was the best we could recommend.

We herewith present Mr. Shedd's report. We submit it in a printed form, in order that it may have a careful examination and be preserved, as we think it deserves to be, for the future benefit of our City Government in their public works and of our families in their household regulations. It will commend itself to you as a text book, not only for the Engineer, but for the student of sanitary reform and domestic economy.

The large manuscript plan, which accompanies this report, gives the location, depth, size and grade of all sewers proposed, in a simple and clear form, which can easily be understood, besides furnishing a reliable map of the city.

Mr. Shedd's exhaustive treatment of the subject leaves but little for your committee to add. We can only enforce his statements by a few comments, that occur to us, as residents familiar with the local conditions, public sentiment and past experience of our communty.

Taunton has no system of sewerage. From time to time, as the demands of particular localities were pressed upon the attention of public authorities, drains have been constructed for the relief of the immediate necessity, without any regard to a general system for the whole city, frequently without reference to the natural drainage of the whole of the particular district in which they were made. In most cases, no provision has been made for future needs of any kind. The petitions were pressed and the work done solely in the interest of immediate abuttors, that they might be relieved at a minimum present cost to themselves. These drains have been built without definite plans and specifications, as to depth, grade, form or materials. Or, if such plans were made, investigation reveals that they were not adhered to. Scarcely any records can be found of these sewers, and even the location of most of them can only be determined by an examination, involving expense. Their construction has been left, for the most part, to the discretion of the builders; if difficulties were met in the process of excavation, they were avoided as seemed convenient, by a change of depth or otherwise, oftentimes to the serious detriment, if not the entire sacrifice of the value of the drain. In one or two instances, error in design or construction has resulted in the entire uselessness of the work; a second sewer becoming necessary in the same street to meet the requirements.

The outfall for most of these drains, in the central portion of our city, is Mill River. This small stream, of

irregular flow, has furnished a convenient receptacle for public and private filth. Manufacturing, waste domestic sewage, drainage of public institutions, stables and Gas Works, privy deposits, garbage and surface washings have here found a common bed, either to be distributed slowly along its banks, or left to putrefy on its muddy bottom, exposed by the witholding of water at the dams above the city, breeding and sending forth poisonous gases and offensive odors in our very midst.

But a large portion of our populated district has not the privilege of draining into Mill River. In a few instances, small natural brooks are availed of as carriers, or artificial surface drains are maintained, which often terminate in low and swampy lands.

A still larger number of our families are unable to rid themselves satisfactorily of their filth and therefore it remains upon their premises, an unwelcome but unavoidable companion, for periods of six months or a year at a time. Some of this class who had the ability to do so, have built costly cess-pools and vaults, in whose protection they have felt secure, until accident or imperfection caused a polluted well, a defiled cellar or offensive odors. But, by far the greater portion could not provide these expensive conveniences themselves, hence, surface sink-drains, open vaults, and standing water are common sights in our community. Besides this pollution of the air, water and soil, as a result of imperfect drainage, saturation of the subsoil prevails to a large extent and is in some localities the greatest existing evil. You are well aware that many of the better class of

dwellings in our city are troubled with water in the cellar. This recurs every year and continues for a period, greater or less, according to rainfall. The clay bottom under the greater part of our city prevents the natural subsidence of soil-waters, which takes place on gravel bottoms. Hence, as the snows melt or rain falls, the subsoil becomes saturated, the level of moisture in it rises, until it reaches the level of the cellar-bottoms, where it remains until a slow absorption takes place, unless removed by an artificial drain. Artificial drains are of no use without a falling outlet, which can not be obtained in many localities for want of public sewers, or because such sewers have unfortunately been built too shallow to drain the cellar bottoms. Another trouble results from this saturation of the subsoil, which is of great public interest, that is, the difficulty of repairing and keeping in good condition our undrained highways. Many of our principal thoroughfares have little or no facilities for surface drainage, and very few can be said to be underdrained. Stone and gravel put upon them are lost from want of foundation, which cannot be had until water is removed. Your committee believe the constant trouble with Weir street, below Harrison, is largely owing to want of drainage; and that all attempts to make a good roadway of this important street, without sufficient drainage, will fail, in the future as they have in the past. The same may be said of many other highways.

This, in a brief and general way, is the present condition of things in our city, as revealed by investi-

gation. Lengthy details would burden this report and are unnecessary.

For many years there has been a growing feeling among the more intelligent of our citizens, and especially among physicians, whose professional training and practice give them a knowledge of sanitary laws and make them intimate with the causes of disease, that much sickness in our community is attributable to the lack of suitable drainage, and the pollution of Mill River. The other conditions of our city and the habits of our population, are, generally speaking, favorable to health. Yet we are afflicted with epidemics of a serious and obstinate nature, which sometimes prevail to an alarming extent.

According to the State Reports of the Board of Health, our death-rate compares favorably with the larger cities, but is considerably above the average of cities and towns; and, in comparing Taunton with other places, we cannot overlook the fact, that a large suburban district is included in our statute territory, whose population, living under more favorable health-conditions, reduces our average death-rate. We believe that a report upon the city proper would be less favorable.

The severe prevalence of diphtheria among us for the past few months is a warning, which we ought not to let pass unheeded. Its ravages have brought great sufferings upon our people, and we can but feel, that, to a considerable degree, it might have been prevented. Although it may not be in the power of Public Author-

ities to prevent dampness and foul air in dwellings; yet, unless they provide the proper means of removing water and filth, the people cannot make their homes healthful. Whatever measures are necessary, for the prevention of disease, should be enforced, so far as practicable, by the Board of Health. But they must have the means of relief to offer in pure water and good drainage.

"Diphtheria is quite universally classed among the so-called filth-diseases." The Massachusetts Board of Health, after a thorough investigation, says of it: "Bad drainage is thought by most of our correspondents to be associated with diphtheria in the immense majority of cases, or that its greatest severity is reached in badly-drained localities; *i. e.*, where the soil is not or has not been properly dried, an evil which may obtain on high as well as on low land. * * * In those towns throughout the State, where especial prevalence or severity of the disease has been marked, there are no sewers. * * * That is to say, the disease has been for the most part one of the unsewered towns. * * * That, where other circumstances assist, its spread is promoted by dampness or moisture of soil, whether naturally existing or produced, especially with a tough, impervious sub-soil."

Similar conclusions are arrived at upon investigations elsewhere. The origin of this scourge is in filth and dampness, its growth by contagion may carry it into the clean and dry homes of the neighborhood.

Aside from epidemics and diseases of acute and fatal character, the results of bad drainage show, in our com-

munity, in a prevalence of sub-acute disorders; inflammatory diseases of the respiratory organs, especially bronchitis, rheumatic affections, chronic perversions of digestion, and a generally debilitated condition, which disables the sufferer from performing his duties. These are all classed by the Massachusetts Board of Health as caused by damp cellars.

The duty of providing relief from the condition of things existing here, by a good system of sewers, will not be denied, if it can be proved that sewerage will bring relief.

Dr. Buchanan in a report to the medical officer of the British Privy Council, makes the following showing of the beneficial results from water supply and drainage in twenty-five cities and towns, with an aggregate population of 593,736. In an average of about seven years the average death-rate of all the places, per 10,000 of the population, had decreased as follows:

From all causes, from 247.55 to 219.87, or an annual saving of 1643 lives.

From typhoid fever, from 13.34 to 7.80.

From pulmonary consumption, from 33.44 to 27.30.

The construction of the present system of sewerage of Chicago was begun in 1856, and at the close of 1860 about fifty-three miles had been laid, "the sanitary effect of which," says their last annual report, "was to diminish the death-rate from 2.46 per cent. per annum in 1855, to 1.88 in 1860," being an annual saving, in

four years after the construction of sewers was begun, equal to 116 lives in a city of the size of Taunton.

Mr. Chesbrough says, in an article on this subject, printed in the Report of the Massachusetts Board of Health. "The most satisfactory, and generally convincing arguments in favor of sewerage are those obtained from an experience sufficiently extensive as to time and population. Bills of mortality are appealed to usually, and, with the exception of a few anomalous cases, susceptible either of remedy or satisfactory explanation, show, both for European and American cities, a very favorable result."

Admitting the importance and desirability of sewerage as affording great advantages of health and comfort, the practical tax-payer will ask the question, "will it pay." Mr. Latham has submitted a peculiar form of calculation by which to determine the money value ot the results of sanitary improvements in a community, taking as an example the town of Croydon, England. This place had had sanitary works in operation thirteen years, with an average death-rate less by 5.1 persons to every 1,000 inhabitants than the average rate of the seven years before the introduction of the works. This showed a saving in thirteen years of 2,439 lives, of which 1,317 were estimated to be able-bodied persons, whose average net earnings, according to Dr. Farr's computations, were £19 10s each per annum. For every death averted, it was estimated that at least twenty-five persons escaped sickness and the consequent loss of time,

medical expenses, etc. With these data the following results were obtained :

2,439 funerals, etc. saved, at £5 each,	£12,195 0s
60,975 cases of sickness prevented, at £1 each,	60,975 0s
8,560.5 years labor of persons saved from death, at £19 10s each,	166,929 15s
	£240,099 15s

The total cost of the Croydon sanitary works at that time, including water supply, sewers, sewage farm, public baths, etc. was £195,000. Thus in thirteen years, the saving effected by these works, as above determined,—saying nothing of the misery attendant upon sickness and death, that was averted,—largely exceeded their cost of construction.

In 1874, the Massachusetts Board of Health considered this question of the value of health to the State in a money sense ; or in other words, the cost of sickness and disability resulting from lost opportunities to earn wages, and from attendant expenses. Their well based calculations showed the following astonishing result on an assumed reduction in the death rate of 4 in 1000 persons. The saving in life according to the then population would be 5,604, indicating a total loss of 4,090,920 days in one year by reason of sickness and disability. The minimum average income was estimated at $1.00 per day, and the expenses of sickness at as much more. These would amount on the total sickness of the State, to $8,181,840 per annum, or for the working population

alone to $3,190,916, leaving out of the account the Croydon item of burial expenses. The $3,190,916, a direct, tangible, continuous saving to the State, would represent, capitalized at 6 per cent., $53,181,933, an amount which could be invested without loss in such sanitary improvements as would effect a reduction in the death-rate of 4 per 1000 inhabitants. The incalculable gain would be the escape from a considerable share of "the pauperism and crime directly traceable to the paralyzing influences of debt incurred by sickness." The average minimum death-rate for the State was fixed at fifteen per 1,000; although in a few towns, as low as ten to eleven have been recorded; but in England the general minimum of seventeen is the point aimed at. The latter computation of the Mass. Board of Health, applied to a city the size of ours, would show a money-saving alone of over $40,000 per annum.

A comparison of the annual expenses of our city with those of other cities, will show that the expenditures of our Poor and Alms department and Highway department are both disproportionately large. An investigation of the details of the former will show that the amount of alms distributed in temporary relief is very large, and that many of the persons, thus helped, are reduced to their condition of poverty by sickness and death in their families. The cost of the recent epidemic to your Treasury is tangible, direct and of considerable amount. Prevention of sickness would be a positive gain to the taxpayer, in reduction of cost of this department. In the Highway department, a much less

sum expended would keep our streets in good condition, if they were properly drained. Excellent authorities testify to this, as referred to elsewhere in this report, but your own experience has undoubtedly taught you this fact. Bad roads are concomitant with wet, clayey soil.

But, perhaps the strongest practical argument, which can be presented to our taxpayers, in favor of the adoption of a general plan of sewerage which shall form a complete system, is, that it will stop the expenditure of public funds in works of only inferior and temporary value. Sewers will be called for in the future as they have been in the past. Quite a number of petitions for them have recently been presented. The demands of the people must be heeded and considerable amounts will be expended every year. If we go on in the way we have, nothing can preclude the possibility of a wasteful expenditure. Necessity will compel the removal of pollution from Mill River, expensive alterations will have to be made and our investments will prove to have been of no permanent value. Your committee are fully aware, that but a small proportion of the sewers projected will be required at present, but it is of paramount importance that every separate sewer, to be built, should conform to and form a part of a general system of lasting value. Your committee make the following

RECOMMENDATIONS:

First. The adoption of the plan proposed by Mr. Shedd. We believe that a thorough study of the questions involved will convince you of its excellence. And

think the city is to be congratulated upon having been able to secure so valuable a scheme and so simple a method of ridding itself of its sewage.

Second. The creation of a Sewer Department, by which safeguards shall be provided for the faithful adherence to the adopted plan, the efficient management of the construction of public sewers, the proper surveillance of all connecting private drains, the economical expenditure of funds and the preservation of complete plans and records of the work. The proper organization of this department, whether it be a commission, or a committee of the city government, is of vital importance. The permanent character of a commission would, in the opinion of your committee, tend more to ensure competent management. The plan, after being partly carried out, ought not to be so changed or modified as to impair its efficiency, which might happen, if new men should be placed in charge of it. In this connection, your committee suggest the expediency of the appointment of a City Engineer to superintend the construction of sewers. Aside from the necessities of an Engineer in this department, it would seem wise that the other material work of the city should have the benefit of Engineering ability. The important department of Highways, including sidewalks and bridges, involves much in the location of lines, establishment of grades, construction of earth-works and masonry, which should have the attention of a skilled Engineer, who would be responsible to the city. Our past experience has taught us that neglect in this matter is very expensive in the end. Your committee are

anxious to have such measures taken, as will ensure the complete success of the proposed plan.

Third. The construction, at the earliest practicable moment, of the proposed central main sewer and the intercepting sewer, which begins at Chandler avenue and runs to the central main sewer at Weir street. The necessity of the main sewer and outfall, before building any others, is of course apparent. The reasons why your committee recommend the immediate building of the above described intercepting sewer, are these. The State Lunatic Hospital needs some better method of disposing of its sewage. It has over 800 inmates, (patients, officers and others) and uses over 50,000 galls. of water per day. The immense quantity of filth and waste from this institution is now retained upon the premises, except so much of the liquids as drain into Mill River. The authorities have been considering various plans of treating this sewage on their premises, so as to remedy the evils that now exist. Any such plan which they may adopt will involve a large original outlay and considerable expense of maintenance. Your committee have good reason to believe that they would decidedly prefer to deliver their sewage into the city sewer and pay a fair and reasonable sum towards the cost of the construction thereof. As their need of relief is urgent, it seems wise for you to give this immediate consideration. Then, by building this sewer, we will be able to remove what we believe to be the causes of sickness in that neighborhood, viz: the pollution of the air and of

Mill River by the Hospital, Jail, and domestic waste of an offensive nature.

The estimate of cost of these proposed sewers is as follows:

From the Hospital wall to Ingell street,	$86,095
From Ingell street to the outfall,	28,005
	$114,100

This includes all appurtenances, as manholes, catch basins, etc. and crossing the river on Washington street and Weir street. Whether it will be deemed necessary or advisable to build the entire main sewer beyond Ingell street at present, is for future consideration. Your committee believe that an outfall near Weir bridge may be maintained without injury or annoyance or some time.

In conclusion, your committee would express their conviction that the subject of sewerage is by far the most important one for your present consideration. We would remind you that you are guardians of the public welfare, that you have accepted solemn responsibilities, and that you will be held accountable for the faithful and vigilant performance of your duty to protect the health of your citizens.

The introduction of pure water has already proved a great benefit to our city; add to this a good system of sewerage and Taunton can take her place in the first rank of cities, and material prosperity will result therefrom.

Your committee, in endeavoring to keep this report within reasonable limits, have been obliged to omit many details and the discussion of some matters of importance, such as methods of payment for sewers, assessments, etc.; these must be made the subject of investigation and report, after the adoption of the plan.

Respectfully submitted,

WM. H. BENT.
GEO. H. RHODES.
WM. TINKHAM.

REPORT

AND

PROPOSED PLAN,

BY

J. HERBERT SHEDD, C. E.

Messrs. Wm. H. Bent, Geo. H. Rhodes, Wm. Tinkham, } *Joint Special Committee on Sewerage.*

Gentlemen :—

In accordance with your request I have made careful examinations of the City of Taunton, and its surroundings, with reference to the construction of a thorough system of sewerage, upon which I now submit the following

Report.

NECESSITY FOR SEWERAGE.

The subject of Sewerage in its relations to health and the comfort and social improvement of communities, has been so long and exhaustively discussed that it can hardly fail to be more or less familiar, in a general way at least, to most of your citizens. It is not, therefore, proposed to burden this report with any extended remarks upon the necessity for sewerage in crowded centres of population ; but only to refer briefly to the leading points of this branch of the subject.

First. The establishment of water works in a city is inevitably followed by largely increased use of water, which, after being fouled, must be disposed of ; and in the absence of sewers, the first effort to get rid of such wastes, is either by turning them into a tight cesspool

where they are allowed to remain and stagnate, generating dangerous gases; or into "dry-wells" to soak into and contaminate the soil; or they are turned directly upon the ground, to steam up, in warm weather, in unwholesome vapors, and gradually saturate the soil with their poisonous elements. Such accumulations of filth in the soil around dry-wells and leaky cesspools, and wherever surface deposits are made, "are as certain to be followed by injurious effects upon the health of the people whose houses are near such influences, as is any other violation of sanitary laws."

Another result of an ample supply of water under constant pressure, is the extended use of water-closets, the wastes from which must be discharged into cesspools if there are no sewers.

Second. The worst, and at the same time the most common nuisance, in a sanitary sense, that exists in a populous community, is the privy-vault. Nothing has been more clearly proved by the investigations of medical science, than that the accumulations of decomposing organic matter, especially human excreta, are "hot-beds for the propagation of disease;" and undoubtedly many "mysterious dispensations of Providence" have had their origin there.

Some of these vaults are kept in as tolerable condition as circumstances will permit, but a majority of them are store houses of reeking putridity, whose exhalations rob the air we breathe of its vital element, oxygen, or load it with the germs of specific diseases. Another but less direct form of pollution is by soakage through the soil into wells, and sometimes by surface drainage into them.

The diseases most directly traceable to this subtle poisoning of air and water, are those of which typhoid fever is a type, and are known as a class under the expressive name of "filth diseases." But its most wide spread and therefore most disastrous results are a general debilitation of the system, a lowering of the natural vitality, by which the victim is rendered susceptible to disease, and unable to resist its assaults. The late Dr. George Derby, of Boston, said: "There can be no doubt that the power of resisting diseases of every kind is diminished by habitually breathing air so polluted that not only the enjoyment, but the duration of life is abridged, and the liability to destructive epidemics is thereby increased." Numerous health reports and sanitary works teem with proofs, too conclusive to be disputed, of the subtle danger lurking in tainted air and impure water.

It is safe to say that not one privy-vault in a hundred is kept in a condition of certain safety to health; for decomposition of their contents begins in about twenty-four hours after deposit; and the accumulation is dangerous in proportion to its age. Hence, the only absolute safety lies in its being daily removed, or covered with absorbent material, neither of which is practicable for large and dense communities by any pail or dry-earth system yet devised.

Deodorization is sometimes resorted to, but this is about as impracticable as the other methods. Moreover, there is no certainty that it affects anything beyond the neutralization of a fœtid smell, which is not very import-

ant; for as such odors are not necessarily injurious to health, so on the other hand the most dangerous gases from decomposing filth may give out no warning smell. Hence, it is not safe to rely upon the fact that the contents of a privy-vault or cesspool do not assail the nostrils.

John Simon, Chief Medical Officer of the Privy Council of England, says: "It is of the utmost practical importance to recognize, in regard to filth, that agents which destroy its stink may yet leave all its main power of disease production undiminished." The only absolute safety, therefore, against excreta, is in being *promptly and completely rid of it.*

Third. The immediate removal of storm-water from the streets of a city, is obviously important. Mischief and costly repairs to street surfaces, and damages to private property, recoverable in a suit at law against the city, would be the frequent results of allowing it to take its own course by natural surface flow.

Fourth. Excessive moisture of the soil is an evil against which a city should provide, both for sanitary and economical reasons.

It has been conclusively proved, both in this country and in England, that "residence on damp soils tends to the production and promotion of consumption." It is sufficient to say of the reliability of this conclusion, that the most important of the investigations on which it is based were conducted in this country by Dr. H. I. Bowditch, of Massachusetts, and in England by Dr. Buchanan, then chief medical officer of the government. The

Massachusetts Board of Health has emphatically declared against wet or damp cellars, as the cause, not only of diseases of the respiratory organs, but of a gradual undermining of the constitution.

There is another objection than the sanitary one. Such cellars depreciate the value of an estate—often to a very serious extent — for storage purposes. Basements of business blocks are sometimes positively unrentable, and that which might otherwise prove a source of considerable income is useless, or worse than useless, property to the owner.

Another difficulty resulting from undrained, clayey, retentive subsoils, like that which generally underlies the city of Taunton, is in the proper maintenance of highways. Under such conditions the street foundations, and the ground generally, are much of the time in a state of saturation.

It is all-important to the securing of a good street, that water should be kept, not only from its surface, but several feet below it.

Especially is this necessary in the winter and spring, when undrained highways, no matter how well maintained otherwise, are often badly broken by the action of frost, the severity of which is in proportion to the degree and depth of moisture. It is very well known that our highways are at their worst after the breaking up of winter, and that in one or two of the spring months more money needs to be expended on them than in all the year besides.

A part of Middlesex, England, like Taunton, is flat, with a clayey subsoil. The Superintendent of Metropolitan Roads once stated that after trying shallow drains there, which dried off the surfaces without strengthening or hardening the foundations, he underdrained them to the depth of five or six feet, and "from that moment the maintenance did not involve half the previous expense."

Gillespie says: "The drainage of a road is one of the most important elements in its condition. All improvements are useless till the water is thoroughly got rid of; and a bad road may often be transposed into a good one by merely providing for carrying off immediately all the water which falls upon it. The water standing beneath the surface causes great injury to the road in lessening its ability to resist wear and tear." Bloodgood says: "The first operation in making a road should be to secure the soil from under-water; that is, thoroughly drain it." * * * "If roads, by a proper system of drainage, be kept dry, they will be maintained in a good state and at a proportionally less expense."

Sub-drainage, especially in retentive soils, is therefore necessary, not only to that condition of hardness and smoothness of a highway by which comfort and saving of horse flesh and vehicles are secured, but to economy of maintenance; and to that end, if no other, anything tending to improve it is worthy the attention of the taxpaying citizen.

The sewers, alone, may not in all cases furnish sufficient drainage; but in many cases they will be sufficient, and

in all cases they furnish necessary outlets for such further drains as may be required.

NATURAL OUTLETS.

By gravitation surface drainage flows to accessible streams, and is soon lost in some larger body of water. The tendency to dispose of the offensive wastes of life in the same direction is also a natural one; and when this disposal is accomplished by a system of drains having direct and unbroken connection with our water-closets, sinks, etc., it is known as sewerage.

The unequalled advantage of a good sewerage system lies in the fact that while no other method even *attempts* to provide for the effectual disposal of anything besides excreta, the former not only sweeps completely and promptly away all kinds of sewage as fast as made, but provides a ready escape for storm and sub-soil waters.

If the stream into which sewage is thus discharged is of such size as to very greatly dilute it, and has sufficient current to carry it beyond the limit of danger or annoyance, such a method is clearly advisable. It is not only the most expeditious and effectual, but the most economical method now known; for, notwithstanding the fact that a considerable actual manurial value is apparently thus lost, no process has yet been devised by which it can be recovered at a profit.

Cities within easy reach of tidal currents, whether upon the sea-coast or large rivers, have special advantages, as to location, for this summary and economical method of

getting rid of their water-closet, urinal, sink and other wastes, while without these advantages many inland cities have regarded the immediate benefits of such disposal as outweighing all other considerations, and have adopted it in the face of the objectionable fact that their out-fall must be connected with small fresh-water streams—sometimes mere brooks—to the probable contamination of the water past fitness for use by the inhabitants below; or, either directly or indirectly, with ponds having few or no outflow currents. "Thus while the crowded population is relieving itself, effectually and economically, of its refuse and waste materials, it is turning them over in the shape of defiled water to the injury and abridgement of the rights of every riparian owner."

Many English cities and towns have at length so defiled these inland waters that they have been compelled by law to remove all offensive matters from sewage, by chemical treatment, irrigation or filtration, before discharging it. It is probable that several cities in this country will soon be compelled to adopt some plan for the purification of their sewage before it is discharged.

WATER-CARRIAGE.

The good results of a properly planned and faithfully constructed sewerage system are not a matter of speculation. The history of many such works, in this country and in England, show beyond a doubt that immunity from the evils to which I have referred may thus be readily secured to communities located as is the City of Taunton.

"The full benefit of a public supply of water cannot be realized in the absence of sewers nor can all the comfort and luxury of the family be enjoyed without the service of both the modern water-supply and effectual sewerage. The water carriage system of conveying sewage from our premises, falls naturally into harmony with our present notions of the application of labor-saving machinery to the promotion of human comfort and improvement. Its popularity is derived from the fact, that after the apparatus of water-closet, urinal, sink, bath-tub and waste pipe in the dwelling or manufactory, are once properly arranged and connected with the sewer, their operations go on, silently and constantly, with but little care or attention on the part of the users."—*Ball.*

"The water-carriage system is gaining in favor throughout the civilized world. With care, it is the most convenient and the least objectionable method, and of the greatest advantage in a sanitary point of view, although there are evils peculiar to it which should be carefully provided for. * * * For our climate and our people, at least, there is absolutely nothing which can take the place of well-ordered water-closets."—*Mass. Board of Health.*

"Experience has fully shown that the dangers to health are least under the water-carriage system, if properly managed; and the common-sense of the community has declared it the most decent and most convenient."—*Dr. Folsom.*

PLAN.

The fullest attainable success of a system of sewers depends upon a careful regard to all the elements that enter into their construction, — as sizes, grades, forms, depths and materials.

Another requisite to final success is unity of plan. Each of the drainage districts into which the city is naturally, or is to be artificially, divided, should at the outset be completely planned for sewers with reference to future wants as nearly as can be determined. Few of them, it may be, will at first be required; but, few or many, they should be constructed as parts of a comprehensive system. Mistakes resulting in expensive re-construction or endless and ever increasing troubles, will thus be avoided.

Success largely depends, too, of course, on thoroughness of construction; and to this end the work should be under constant, intelligent and faithful supervision.

EFFICIENCY.

The chief point of a good sewer is a proper velocity of flow, which is essential to its most important work—the removal of ordinary sewage when no storm water is running. The flow of ordinary sewage is always small compared with that from even an ordinary storm; and unless every advantage is improved to give rapidity and uninterruptedness to the flow there will be settlement and deposit of matters in suspension upon the bottom of the sewer. In time these deposits increase to such an extent

that they must be removed by "flushing" water through the sewer or by scraping. But if the deposit can be prevented without artificial means the sewer is said to be "self-cleansing," and its highest success is attained.

This essential point—velocity of sewage flow—is secured by a proper combination of grades, sizes and shapes, and the use of such materials as will offer the least frictional resistance to the currents.

In its sanitary results the superiority of a sewer which keeps itself continually clean, over one which does not, is incalculable. In the former all those elements of sewage which become dangerous by putrefaction are swept entirely away before that condition is reached; while in the latter it remains to stagnate in constantly accumulating quantities, from which dangerous gases are generated to inflict debility and disease upon the occupants of any house that may be imperfectly connected with the sewer.

The economy in the maintenance of self-cleansing sewers is well illustrated by the experience of the city of New York. Many of the older sewers there are too large, —or otherwise improperly constructed,—to be self-cleansing, while as a rule those more lately laid are so, being smaller and always of smooth pipes where the requirements of size will admit. A report of the Croton Aqueduct Board upon the sewers of that city shows that during the previous year the cleaning and removing of deposits from the 261 miles of brick sewers then in use cost $106.25 per mile, while the same service for the 60 miles of pipe sewers cost only $8.33 per mile.

Brick sewers, however, may be and at the present time generally are, made self-cleansing by a careful regard to sizes and forms, both in plan and execution, if, as is generally the case, a suitable inclination can be secured.

The second duty of a sewer is the removal of storm-water; and for this, the important point to be determined is its maximum capacity, or measure of greatest discharge. The elements which enter into this problem are the greatest quantity of water it is proposed to carry off in a given time, and the velocity of flow which can be secured; and the solution of the problem gives the proper size, or sectional area of the proposed sewer.

The element of quantity is determined by the area from which drainage passes through a sewer at any given point where its capacity is to be fixed, modified by the slope and character of the surface and the rate of rainfall. It is now the general practice to construct sewers no larger than will carry off the drainage into them from a storm of an inch an hour, the quantity reaching the sewer within the hour having been determined by numerous tests to be, excepting in rare instances, not more than one-half the above rate of fall,—from urban territory having ordinary surface inclinations. On the flat territory of Taunton it is probably something less than that, as a rule, which would give a margin of safety against overflow during excessive storms, if your sewers are constructed as proposed upon the above basis.

Few storms in this part of the country, at least approximate a rate of one inch per hour; and much less than one per cent. in an average of years will exceed it.

The complete accomplishment of this purpose of a sewer would of course be the immediate removal of *all* storms, however heavy; but economy of construction, and efficiency of operation of the sewer during dry weather, when only the minimum of ordinary sewage is flowing, alike forbid it. Long experience has proved beyond question that it is unwise to make sewers of greater capacity than will serve to carry off the water gathered from a rain-fall of an inch an hour.

The third requisite of a sewer is sub-drainage of the street and the abutting premises; and the necessary conditions are, a sufficient depth for the sewer, and porosity of the materials of which it is constructed.

GRADES.

With steeper inclinations smaller and therefore cheaper sewers, having the same discharging capacity, may be laid than with flatter grades; and, as was stated in speaking of velocity of flow, the scouring or self-cleansing effect is enhanced, and the cost of maintenance and the danger to health reduced to a minimum.

Hence, if grades, like sizes, could be determined at will by the engineer, much of the difficulty, and something of the cost, of constructing a thoroughly and uniformly efficient sewerage system would be obviated. But the determination of the grade of a main sewer is sometimes restricted by the unfavorable grade of the street in which it is located, the position of its outfall, or the requirements of connecting sewers in contiguous streets. These lateral sewers may in their turn be restricted in grade by

minimum depths at one end and the position of the main sewer, with which they must connect, at the other. In such cases every possible advantage should be taken of the favoring conditions.

Uniformity of grade is desirable, but that, too, is often impracticable. *Trueness* of grade, however, which is also important, is always attainable through skillful and honest construction; and these should be insisted on at every step in the progress of the work.

The common impression that the rate of flow in a channel depends unconditionally upon the inclination at which it is laid, is an erroneous one. Grade is an important element, but so, too, are sizes and forms. A street gutter laid at an inclination of six inches in a hundred feet, or at a rate of fall, as usually expressed, of 1 in 200, may not be self-cleansing, while a sewer of suitable size, running half full or more, may be laid at an inclination of two feet in a mile, or 1 in 2640 and be completely self-cleansing. Or, a sewer laid at a grade of 1 in 400, but too large, or of improper shape to contract the flow, may have less velocity and scouring effect than another sewer with less than one-sixth the rate of fall but of smaller size and contracted channel.

This point is well illustrated by two conspicuous examples:—The minimum fall of the sewers of Paris is 1 in 1,000, or about five feet to a mile. These sewers collect deposit, although they receive no house drainage, and have to be cleaned out artificially at an annual cost, for the 217 miles, of about $150,000. On the other hand the northern outfall sewer of London, which has a fall of only two

feet to a mile, or 1 in 2,640, but of more limited size proportionately and of better shape, requires no artificial cleansing.

Mr. Wicksteed has found by experiments most carefully made, that "with a bottom velocity of 16 inches per second only, (or 0.90 miles per hour,) heavy pieces of brick, stone, &c., will be removed, and that with a velocity of $21\frac{3}{4}$ inches, (or 1.24 mile per hour,) even iron borings and heavy slag will be removed. The above minimum velocity will therefore be sufficient."

Mr. Beardmore states in his work on Hydraulics that "a velocity of 150 feet per minute, or $1\frac{3}{4}$ mile per hour) will generally prevent deposit in pipes and sewers."

This was corroborated by the observations and experiments of Mr. John Phillips, who had a long experience with the London sewers. He found "that it required a constant velocity of current to be running through the sewers equal to about $2\frac{1}{2}$ feet per second, or about $1\frac{3}{4}$ mile per hour, to prevent the soil from depositing within them."

Mr. Bazalgette, referring to the above opinions, says they are confirmed by his own observations and experience, which lead him "to regard a mean velocity of $1\frac{1}{2}$ mile per hour, in a properly protected main sewer, when running half full, as sufficient." This is equivalent to $2\frac{1}{5}$ feet per second.

I am of the opinion that for the large sewers, having more uniform flow, a velocity of $2\frac{1}{2}$ feet per second is sufficient to render them self-cleansing from all matters properly admitted.

The smaller lateral sewers, whose flow during dry weather, of sewage alone, is intermittent and at the best very shallow, should be laid to give a somewhat greater velocity of flow,—say 3 feet per second. This for a 12-inch sewer, running half full, would require a fall of, say 4 inches in 100 feet, or 1 in 300.

For sewers of suitable form and interior surface, running half full or more, the inclination necessary to secure a certain velocity depends on the size,—being less for the larger sizes. Thus,—for a circular sewer one foot in diameter a fall of 1 in 300 is necessary to secure a velocity of three feet per second, while the same velocity would be secured in a circular sewer thirteen and one-half feet in diameter by a fall of 1 in 4,000. It is thus apparent that it is not a standard rate of inclination that is to be sought in order to secure clean sewers, but a standard velocity.

Where the standard velocity cannot be obtained the sewers will need cleansing by some artificial means. Flushing by a large volume of water is a cheap, and, usually, all-sufficient means for this purpose.

The new main or out-fall sewer for Brighton, England, built in 1874, is $7\frac{1}{4}$ miles long, and the larger part of it is 7 feet in diameter. Its average rate of fall is 3 feet to the mile, but for a mile in length near the outlet, the fall is only one foot. When there is no rain the depth of flow is from 6 to 12 inches, and the maximum velocity 84 feet per minute. This sewer drains about 1,800 acres, and it needs to be flushed with tide-water, or from the hydrants to keep it clean.

During the last season I constructed for the town of Brookline, a main sewer about $1\frac{3}{4}$ mile in length, of which the greater part is 6 feet, by 7 feet, and 7 feet in diameter. It has a fall of 1 in 2,000 and drains about 1,200 acres. Two flushing-gates are built in the sewer for use in case of need. During construction considerable mud was let into the sewer, and by operating the gates it was washed out and the sewer left quite clean.

It is in contemplation to construct for the city of Glasgow an intercepting sewer to take its sewage to the sea, a distance of 27 miles. It will be at depths varying from 20 to 270 feet below the surface. The rate of fall will be $10\frac{1}{2}$ inches in a mile, or 1 in 6,034. It is estimated to cost about $7\frac{1}{2}$ million dollars.

Work has been begun in Boston upon a scheme of intercepting sewers, of which the portion now contemplated is estimated to cost $3,712,700. The rate of fall for the main sewers is to be 1 in 2,500, and for the secondary sewers 1 in 2,000.

I think it is not uncommon to construct main sewers at a rate of fall of 2 feet in a mile, and, as we have seen this is a suitable grade if only the conditions are such that a proper velocity can be maintained.

While the grades which I propose for some of the sewers of Taunton, may seem to those unfamiliar with the important sewerage systems of the world, so slight as to give much trouble, experience has proved that if the work is properly executed and faithfully cared for, the sewers may safely be relied upon to fulfil their use in a satisfactory manner.

SIZES.

Within twenty-five or thirty years it was the general practice in England to construct all common sewers of enormous size compared with the work they had to do; and none of them were so small but that a man could easily enter them, as indeed they commonly had to, to clean them out, for the very reason that they were so large; a self-cleansing current could not be maintained in them.

The sanitary reformation at about that period led to the introduction into use of smaller sizes. For a few years a bitter warfare was waged against the "innovation"; but experience has long since proved the correctness of the theory on which they originated. No one who has given the subject unbiased attention now doubts the superiority of the present system over the old one.

"As regards the necessity for entering sewers, which was dwelt upon so much ten years ago," (this was written in 1865,) "the successful use of the small sewers shows that this necessity does not exist."—*Kirkwood.*

The smallest size that is recommended for a common sewer, and the one of which more is laid than any other, is twelve inches in diameter. They are, however, laid in England as small as eight inches, and occasionally in this country, nine inches.

A 12-inch sewer, if of smooth pipe, will, at any grade which will make it self-cleansing, carry off from at least four acres, entirely populated, all the ordinary sewage flow, and the surface drainage during a rainfall of an inch an hour; and with more favorable grades it may drain

twice as much. Sewers into which these discharge, or which directly drain larger areas, must of course be proportionally larger.

The sizes proper for the various localities are closely determined, with reference to efficiency on one hand and economy on the other, by a formula into which all the determinable elements of the case enter. These sizes are modified to conform to local conditions, which cannot be expressed in a formula.

FORMS.

The only forms, or sectional shapes, now employed in systematic sewerage, are the circular or some combination of circular arcs, the usual variation being the egg-shape or oval, with the small end down, for medium sizes. These forms are best adapted to secure a scouring effect on ordinary sewage flow, while offering the least frictional resistance for the volume of water carried when running full or half-full with storm water.

MATERIALS OF CONSTRUCTION.

As it is beyond dispute that smooth surfaces of channels offer least resistance to the flow of liquids, so it is certain that when perfectly made the vitrified and salt-glazed stone-ware pipes now so commonly used are on that account superior to brick-work for sewers. The 12-inch size is cheaper, too, than brick-work of the same size; and for a 15-inch sewer the cost is about the same; while the 18-inch pipe, although costing something more than brick-work, is of greater discharging capacity.

As to strength, they have been submitted to very severe tests, and most brands, of sufficient thickness, have clearly shown their ability to withstand any pressure of earth that will be brought to bear upon them when in ordinary places. In this respect they are quite as reliable as brick-work.

Eighteen inches in diameter is the limit, as to size, of the successful manufacture of pipes.

It has been my uniform practice to use glazed pipes where a 12-inch size is required. For situations where a 15-inch or 18 inch pipe would be suitable, I have been governed by the circumstances of the case in choosing between pipe and brick, usually making the sewer slightly larger if of brick.

Sewers larger than eighteen inches in diameter should be built of brick; and the utmost care should be exercised in the selection of materials and in the formation and interior finish of the sewer.

Every barrel of cement proposed to be used upon the work, should first be tested, and all failing in strength should be rejected. I have caused tests to be made on more than fifty thousand barrels of cement, and found this the only certain way to secure the rejection of poor materials, and the consequent avoidance of weak places in the work.

Cement pipes, made of sand and hydraulic cement, and moulded into short lengths of the proper form, have been used to some extent in this country, but less so than formerly. I cannot recommend them. The great objection

to them is their uncertainty of quality, because poor cement may be used, or the materials be improperly worked, or both. Such pipes cannot be depended upon to withstand pressure in the trenches, and they are very liable to soften and disintegrate by the action of sewage. Besides, they are not so smooth as glazed stone-ware pipes, though more so, when new, if well made, than brick-work. It is claimed for them that they make a somewhat cheaper sewer than pipes or brick; but even that, at the present cost of materials, is a matter of doubt.

DEPTHS.

No depth that can be adopted can be uniformly maintained. Local conditions, as the requirements of connecting sewers, or peculiarities of street grades, may increase or diminish it. For the Taunton scheme I propose a general depth of eleven feet; and this measurement is to the inside crown of the sewer, for that and not the bottom, which is usually taken, is the limit of efficient drainage when the sewer is running full.

This depth may seem excessive, but it is not so. It is hardly the average of established depths in the United States, and is the least allowed in London for a 12-inch sewer; but it will allow for house connections the proper fall of 1 in 60 from the level of almost any cellar bottom, starting from the rear of the building, and will also amply serve to underdrain the soil and house and street foundations.

There is now constructing at Frankfort-on-the-Main, in Germany, by one of the most eminent sewerage engineers

of the world, Mr. W. Lindley, a system of sewerage combining the best sanitary principles known at this day. This work, while in progress, was made the subject of an essay by Mr. Lindley, before the International Sanitary Exhibition at Brussels, in 1876. In regard to the depth of the sewers, he says, —

"The depth of the public sewers below the level of the streets varies from 10 to 33 feet; in the narrow streets of the ancient city the depth reaches even 22 feet; in general we seek to keep the depth between 13 and 20 feet. The average depth is very near 17.2 feet. This great depth was necessary to assure the drainage of the under soil and cellars. The greater part of the public sewers are below the level of the waters of the subsoil or in the bed of impermeable clay. This position prevents in the surest way the escape of sewage waters and the infection of the subsoil."

Greater depths are sometimes required for main sewers than would otherwise seem to be necessary, to enable lateral sewers, through flat territory, to drain into them at a proper inclination, commencing with effective depths at their upper ends.

It does not materially increase the expense of a sewer to lay it deeper, within the limits of a single length of sheeting, which may be taken at about 25 feet. Nine cents per foot in length for each foot of increased depth will probably cover the cost for average sizes in earth like that found in Taunton, and ten per cent on the whole cost of the work, as ordinarily executed, would probably

secure an increased depth of four feet for the entire system.

It is often the case that the benefit to a single estate is enough to pay the whole cost of lowering a sewer throughout a long street.

SEWERS AS UNDER-DRAINS.

Subsoil drainage, or the lowering of the table of excessive moisture below the foundations of buildings and of streets, is effected by the gradual settling away of the water in the soil as it passes through the brick-work into the sewer. The facility with which this process goes on will be readily understood by all who know the porous character of brick. It is not uncommonly the case, that water will pass through a few square feet of brick-work in the filtering wall or screen of a cistern about as fast as a man can pump it out, and that without lowering the clear water surface more than a few inches.

From tests of the rate at which bricks will absorb water it is safe to say that under ordinary conditions one hundred lineal feet of single-course brick sewer two feet in diameter has the capacity to drain from the soil not less than 250,000 gallons a day, and often, no doubt, much more. Much water also passes through imperfect joints. Phineas Ball, C. E., who was several years city engineer of Worcester, says that in two districts of that city the subsoil drainage amounts to the largest part of the contents delivered by the sewers. Such cases are undoubtedly common.

When the Brookline main sewer was completed last year the pressure of the water in the soil against the sewer was found to be so great that as a measure of safety a considerable number of small iron vent pipes were inserted through the masonry. The water continues to the present time to make its free escape from the subsoil through these pipes into the sewer in such quantities that it can be plainly heard at some of the manholes.

One of the greatest troubles in the management of sewers is the loss of water in catch-basins and the consequent unsealing of the traps, by soakage through the brick walls of the basin, unless the utmost care has been taken to render them water-tight.

The lowering of water in wells is a very common result of sewer construction.

The smaller sewers being of vitrified pipes, are not themselves adapted to the work of soil drainage, excepting to the extent that their joints, which are three feet apart may be imperfectly cemented. But such sewers have brick manholes, about one hundred feet apart, which will drain at those points as low as the sewer itself could, and where anything more is called for, small agricultural drain pipes can be laid from manhole to manhole above the pipe sewer.

MANHOLES.

Manholes built up from the sewer to the surface of the street, of brick, with movable iron covers, afford easy access to it for examination, cleaning and repairs. They

are located at every point of change in the direction or grade of the sewer, and on the smaller sizes, intermediately about 100 feet apart. On the larger sewers they may be farther apart. With a light at the bottom of one of these manholes, a person at the next one, unless the sewer be wholly closed, can see any obstacle between the two points, and with jointed rods or other suitable tools, can remove it.

LAMPHOLES.

Instead of connecting one small sewer with another by curves, my recent practice has been to make the junction with two straight lines of sewer, and over the change of direction at the central angle to build a lamphole of brick-work just large enough to let down a lantern. From the manholes at the other angles any part of this substitute for a curve can be fully inspected, which in the case of the curve itself cannot be done.

CATCH-BASINS.

The inlets for rain-water are under the edge of the sidewalk, either at the sides or corners, and take a run of from 150 to 400 feet or more of water, according to circumstances. The water falls through these openings into catch-basins built of brick, from near the top of which a pipe leads to the sewer. Over the mouth of this pipe, but not closing it, hangs an iron hood. The lower part of this hood dips into the water, which stands at the level of the bottom of the pipe-mouth, forming a trap to prevent the escape of foul odors, or of gases, if there are any from the sewers directly into the faces of pedestrians.

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More or less sand and other substances fall into these catch-basins, which settle to the bottom instead of going into the sewers to obstruct them or the river channel, and are occasionally removed. The basins are entered for that purpose through openings, with iron covers, in the stone basin-caps which form a part of the sidewalk.

FLUSHING.

The inclination or fall of a sewer may sometimes and unavoidably be so flat as to require occasional flushing by the force of water from a hydrant, or other source, to clean it out thoroughly. For this purpose the manholes furnish very convenient access with the hose. On many sewers it is practicable to erect flushing gates to retain a volume of water, which may be relieved suddenly, so as to clean the sewer.

Brooks and streams can sometimes be availed of to furnish water for this purpose.

VENTILATION.

If putrescible matter is left for any length of time—as it will be in a sewer not self-cleansing—noxious gases will be generated; and in any case unsavory odors will accumulate. Hence, the need of ventilation, or a change of air in the sewer. The simplest and most economical and so far as I know, the best way, all things considered, to accomplish this is by perforating the iron covers of the manholes. These openings allow a safer diffusion of gas into the air than untrapped catch-basins. Connections

should also be made with chimney flues, rain-water conductors and other vent pipes, where it can be conveniently done, provided there is no danger of conducting the gases to rooms of houses.

HOUSE-CONNECTIONS.

Water-closets and other sewage sources, from one establishment, should be connected with a sewer by a six-inch pipe laid at a fall of not less than 1 in 60, and entered at an acute angle with, and so as to turn the contents down the sewer.

To avoid breaking through the sides of a sewer whenever a private drain is to be connected, which is very objectionable, it is now the practice to insert during construction, and as frequently as they will be wanted, short junction pipes through the brick-work; or, if the sewer is of pipes, at the proper places for such junctions a "branch" instead of a plain pipe is laid. These junctions or branches are stopped till connection is to be made with them.

So far as the householder is concerned, the success of a sewerage system depends largely upon the manner in which his connecting drains are laid. No matter how well constructed the common sewer, if his own work is unskillfully planned or executed, with bad grades, sharp corners and loose joints, that which should afford him convenience and safety may prove a source of annoyance and danger. Hence, all private drains should be planned by a competent person, and laid under the close inspection of

an experienced officer of the city by a drain-layer duly licensed and under bonds for faithful work.

Grease should never be allowed to pass down into a drain, because it accumulates where it cools and in time stops up the channel. It is a more frequent cause of mischief than is generally supposed. All sink water should go through a grease-trap, under the sink, before it enters the drain; the grease will be retained there and can be occasionally removed.

To allow the escape of any gas that may pass the lower trap in the drain, so that it cannot find its way into the house, a vent should be supplied by carrying ample open pipes from the highest points of the household system to the outer air through the roof and by bringing the isolated rain-spouts from the roof-gutter down into the drain. This will also serve during a storm to cleanse the drain.

Such an arrangement, properly made, will induce a continual flow of the outer air through the house drains and serve to keep them as free as possible from an unhealthful condition.

LOCAL DESCRIPTION.

The city of Taunton is situated at the head of navigation on Taunton river, about fifteen miles above Fall River and thirty miles from the ocean. It is the location of important manufacturing interests, for which its transportation facilities are excellent, having direct railroad communication with Boston, Providence, and other important cities.

By the state census the population in 1875, was 20,445, having increased 4,440 in ten years. The number of families was 4,399, and there were 3,162 dwellings, of which 3,072, or over 97 per cent., were occupied. Of industrial establishments of all kinds, there were 158, with an invested capital of $4,986,834 giving employment to 4,462 persons. The nominal H. P. of engines and water wheels was 2,464, but the actual power was about twice as much.

The valuation of the city was $17,326,666. In 1865 it was $7,912,682; showing a gain of 119 per cent. in ten years. The value of manufacturing, agricultural and other products, in 1875, was $7,455,805, which owing to an apparent difference in the mode of classification, I am not able to compare directly with the value of products in 1865.

A city with such advantages is possessed of the chief elements of growth in size and importance; and public improvements tending to the promotion of its social and sanitary condition are effective aids to the same end.

Taunton river flows almost entirely upon the east side of the settled area, but the tributary Mill river, a much smaller stream, runs through a central and thickly settled part of the city.

The territory upon which Taunton stands is generally flat, with an underlying bed of clay supposed to be continuous excepting in one locality, which is indicated by outcropping rocks. In some places there are strata of sand between the clay and the surface soil, and occasionally some gravel. Such conditions, unimproved, are

not favorable to the best interests of a community as has been explained. On the east side of the great river, however, at the south-east corner of the city, the land rises more abruptly.

The undulations of the ground naturally divide the settled part of the city into numerous drainage districts. but better results can be secured by grouping nearly all the sewers into three general districts or divisions, as follows: the first, properly called the Central or Weir-street District, including nearly all the north-eastern part of the city, the northerly section of the western part south of Britanniaville, and the territory on either side of Weir and West Water streets, including Ingell street, that can be drained into them. The outfall of this entire district is therefore below the settled portion of the city, beyond Fifth street. The extreme northerly part of the settled territory—Whittenton and Britanniaville, with an area east of the State Hospital grounds—forms another district, draining into Mill river. The south-westerly part of the urban territory forms the third district, the sewers now planned for which have their common outlet through Second street into the main sewer of the Weir-street District. Whenever the territory south of that portion of this district for which sewers are now planned, becomes sufficiently settled for sewerage, valley streets will be required through which to obtain the necessary drainage outlet to the river. The proposed streets are indicated on the accompanying map.

Not included in either of these Districts is the north-easterly section of that part of the IVth Ward which lies

west of the Old Colony railroad, and which drains into the brook that discharges into Taunton river near the railroad; nor is that portion of Weir Village east of Taunton river included.

The boundaries of the above proposed drainage districts include only the settled portions of the city, or those which may soon be settled.

The area of land taxed in 1875 was 26,507 acres, of which I estimate about 1,600 acres, including streets, are included in the proposed scheme of sewerage.

MILL RIVER.

I understand that it has been suggested to improve and utilize Mill river as a main sewer for that part of the city which naturally drains into it. The objections to such a scheme must, upon reflection, be regarded as of sufficient weight to condemn it.

A small brook may properly be converted into a close main sewer, if it has a continuous natural flow independent of sewage, and a suitable depth for out-drainage and the discharge of lateral sewers into it can be secured. But with larger streams, draining a large extent of unsewered territory, the case is different.

Flowing as it does through the centre of the city, Mill river is too small to serve as an open channel for the flow of sewage; and, on the score of economy alone, it is altogether too large to be converted into a close sewer.

The mere rough-walling and covering of a stream with uncemented stone-work will not be sufficient. This point

is well explained in one of the reports of the Massachusetts Board of Health: "All the unwholesome conditions existing in open streams polluted by sewage remain unchanged when such streams are simply covered, or when they are covered and walled with material of an absorbent or permeable character,—as wood, brick or stone, without good cement. They even become more dangerous as gas generators or conductors of sewage-gas, because they admit air far less freely, consequently their gases are less diluted and more poisonous. At the same time, being less conspicuous, or even out of sight, they may insidiously deliver their poisonous gases within dwellings, or in close neighborhood to windows. And further, such streams, even if suitably covered and walled, may, if their bottoms are left unchanged to absorb and at the same time to retain the commingling sewage, continue to contaminate the earth through which they flow, with the effect of polluting all neighboring wells, and rendering the soil along their banks unsafe foundations for dwellings. The transformation into 'covered sewers,' can be made *safely* only by changing them into *complete* sewers."

No possible sewerage requirements for your city, present or future, can at all justify the expenditure such a thorough execution of this scheme would involve.

The first duty of a sewer, as has been shown, is to remove the ordinary sewage of a city, which is extremely limited in amount. The *maximum* capacity of the sewer is therefore determined by the greatest rate of rainfall, or surface drainage therefrom, for which it is intended to provide. It is a well-established rule, that under ordin-

ary conditions, a sewer should be made no larger than will suffice to carry off, without surcharge, storm-water not exceeding a rate of fall of one inch per hour, which is exceptionally heavy and infrequent,—averaging in this vicinity, since 1864, one in a little less than two years; and previous to that date, according to the records, they were of much less frequency.

But Mill river is the drainage outlet, not simply for the city of Taunton, but for a natural basin of about *fifty square miles*, only a small part of which is, or ever will become, urban in character, requiring sewerage. Being a natural water course, the channel of this stream cannot of course be contracted to simply the sewerage requirements of the populated portion of the area it drains; for it is not probable that the maximum flow, both sewage and storm-water, from the settled portion of the territory,—and that is all a close sewer is required for,—will amount in volume to one-tenth of the present storm-flow of the river. A sufficient capacity to discharge the storm-waters of the country area must be preserved; and the cost of doing this by a close, covered channel would probably be more than ten times as great as to provide, independently, suitable channels for the sewage.

It evidently is not wise to involve the city in the enormous expense of improving, walling-in and covering a conduit large enough to take the surface-flow from fifty square miles — freshets as well as ordinary storm-flows — merely to provide for the disposal of sewage from two square miles, if a better and cheaper way can be devised. This more desirable way is by intercepting sewers, which will be hereafter explained.

Another objection to the use of Mill river for sewerage purposes in any way, is, that then the sewage from that section of the city, being discharged into Taunton river, at a higher point than by the scheme I propose,—nearer to the intake of the Water-Works,—must still pass through a settled part of the city before it is finally rid of.

Another objection is based on future contingencies. While no profit can as yet be obtained by the utilization of sewage, certain English cities situated on small streams, have attained such a density of population that they have been compelled, for sanitary reasons, to render their sewage as nearly innocuous as possible, by chemical treatment, before discharging it into the river, or resort to sewage farming, which gives no better net results, commercially, than the former method. A moderate return, however, serving to lessen the total expenditure, is obtained from the best treatment of sewage by these plans. Taunton may not in many years, and perhaps never reach, that extremity; but when it does, if Mill river is a sewer, its flow into Taunton river must then be cut off and directed through a new sewer, of corresponding excessive size, to a proper point below the city for treatment. It is evident that a much greater expenditure would be required for this than to take the sewage from small sewers at the proposed point of discharge. In addition to this there would be the continuous burden of cost laid upon the city by the treatment of the whole of Mill river for the sewage in it; or, the surface drainage from fifty square miles to get the sewage from two. This, capitalized, would represent another large sum needlessly sunk.

Sewage farming would afford no relief. One of the chief objections to this mode of disposal is, that ordinary sewage being so diluted, that it contains about one cent of manurial value to the ton as it reaches the outfall, yields a troublesome excess of water for agricultural purposes. By this conversion of Mill river into a sewer this difficulty would be increased manyfold. Such a ceaseless flood of water over land would prove very injurious, if not totally destructive to all profitable kinds of vegetation.

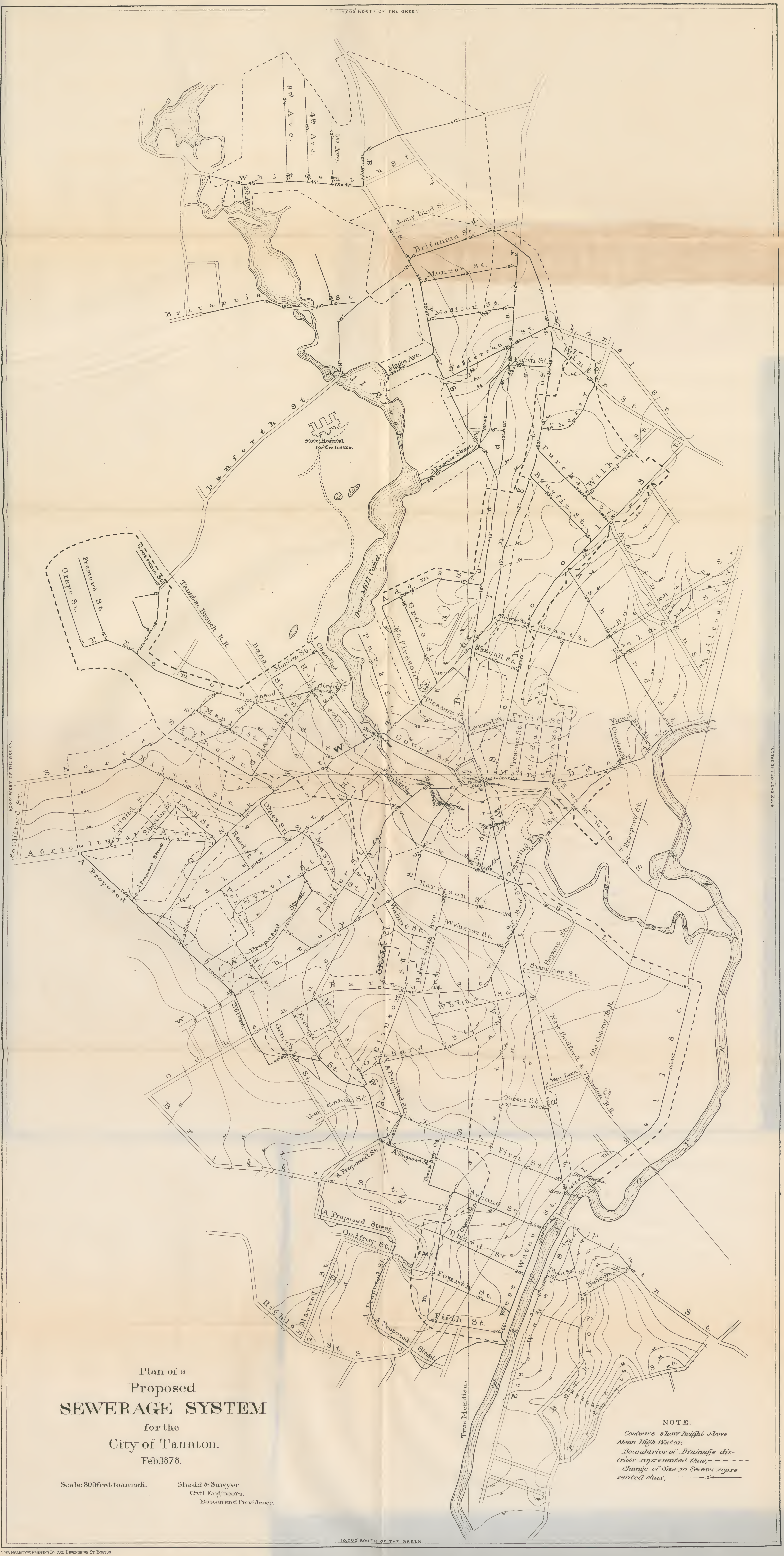
Mill river should therefore remain as it originally was, an open, natural water-course for the surface drainage of a large tract of country. As such, if kept undefiled by sewage, it will always prove a source of health and pleasure rather than of sickness and annoyance.

The plan I propose instead of that just considered, is, to intercept the sewage of that portion of the city which naturally drains into Mill river between the Asylum grounds and Weir street, and turn it all into the Weir street trunk sewer at Main street.

This intercepting sewer practically begins at the intersection of a proposed street and Chandler avenue. At this point is gathered the sewage from Grosvenor, Fremont and Crapo streets, a part of Danforth street and a street tributary to it not named; Tremont street to a point a little east of Granite; Shores street, from a little south of Pine to Tremont; Pine street, from Shores to Granite; Maple and Granite streets and a proposed street from Pine to Chandler avenue; Chandler avenue, Dana and Morton streets and three-fourths of Hodges street. Thence the intercepting sewer runs in a continuation of the proposed

street just named through the Dean Cotton and Machine Company's yard, clearing the important buildings, to Washington street; where it receives the sewage from Washington street; Oak street, from Washington half-way to Pine; the balance of Hodges avenue and Fremont street; and High street from Washington to Wales. Thence it crosses the river, and at the junction of Washington and Court streets receives the sewage from Washington street south of Pleasant and from Park street. Thence down Court street to the south-west corner of the Green, where it receives, by two sewers crossing the river (one at Winthrop and one at Cohannet street), the sewage from Winthrop street north of High; Cohannet and Porter streets to points a little southwest of the Taunton Branch R. R.; High street from Wales to Winthrop; Franklin street and Franklin avenue. Thence to the Weir street sewer; into which all these accumulations are turned to find a common discharge with other sewage, through Weir and West Water streets, into Taunton river below the Weir.

The settled territory north and east of that so proposed to be treated, by a concentration of sewers at the head of and emptying into the Weir street main sewer, also disposes of its sewage beyond the populated limits by the same channel. This territory is nearly bounded by a line including Pleasant, North Pleasant, Adams, Broadway to near Bay street, Washington to a point between Cherry and Fern, two-thirds of Winter west of Cherry, the southerly two-thirds of Wilbur, nearly all of School, Fruit, Union, parts of Dean, Spring and Summer, and Main streets.



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The Main or Central District includes, besides the sections named above, the territory drained through the following streets: High, from Winthrop to Ingell; Winthrop, from south of Walnut to High; Harrison, Webster and Walnut; the northerly halves of Crocker and Clinton and the northerly three-fourths of Harrison avenue, above Barnum; Barnum, from a little east of Harrison avenue; the easterly two-thirds of White; the easterly one-fifth of Orchard; Somerset, from a little south of First; Forest and First; the easterly half of Second; Charles and Third; a portion of Williams court; Fourth, Fifth and a portion of Godfrey; Somerset, from Fifth to a little north of Third; and Ingell and Bow streets.

The intercepting sewer whose location has been described, would fully meet the objections that have been named against the use of Mill river as a sewer, either open or closed. Contamination of the latter, and also of Taunton river, within the settled limits of the city, would be very largely prevented. Instead of waiting and suffering for years, as with an open sewer, till absolute necessity compels a change, a proper condition of things would be ensured from the outset. As compared with the conversion of the river into a close sewer, the proposed plan of interception and removal to a point below the Weir, is also much the more favorable one in the important matter of cost, because of the extremely small size which will serve for an intercepting sewer when storm-overflows can be availed of, as in this case.

STORM-OVERFLOWS.

The flow of ordinary sewage, as elsewhere stated, is a comparatively small matter, and for that purpose alone extremely small sewers would serve. It is for the immediate removal of large quantities of storm-water, which, having entered the sewers, have no way of escape except at the outfall, that large capacities are required. Hence, if surcharge during a storm can be prevented, a great saving in size and cost of construction may be realized. By this reduction in size much is also gained in the efficiency of the sewer, for the smaller the size with a given flow, (within proper limits,) the greater will be the velocity and scour of the ordinary flow, and the more certainly and thoroughly self-cleansing will the sewer be. Still further, should chemical or other treatment eventually become necessary, only sewage of a limited volume would be delivered to the tanks or the farm; and the same results would be obtained at far less cost than if the manurial elements were further diluted by the entire flow of heavy storms.

The surcharge of the proposed intercepting sewer will be prevented by overflows, at convenient points, directly into the river, and its capacity may be reduced to about one-seventh that of an ordinary main sewer draining the same extent of territory.

It may seem as though this method of relief would also defeat the purpose of the sewer by discharging sewage into the river after all instead of carrying it on to the Weir-street main sewer. But it should be remembered that these overflows will seldom occur and last but a short

time ; and, further, that whatever running filth may be in the sewer will have been mainly swept away by the first run from the storm before the sewer fills to overflowing. What is left will be so far diluted as to be undistinguishable from ordinary storm-water. I am confident the river can never be contaminated to any noticeable extent by these infrequent and brief overflows.

For the proposed intercepting sewer storm-water overflows are provided at the following points: one in Washington street, at the crossing of the river; and one each in Cohannet and Winthrop streets, at the crossings of the two tributary sewers.

An important additional advantage gained by these overflows is that they can be availed of by a proper arrangement of gates, to turn water, at any time and in any quantity, from the river *into* the sewer, to flush it out.

The main sewer of the Central District, (through Weir and West Water streets,) is to be relieved by storm-overflows at the following points : one at the junction of Weir and Main streets ; one at the crossing of Mill river ; one at a point in the Ingell street sewer just above its junction with the main sewer; one in the main sewer just below the Ingell-street junction ; and one opposite Second street, at which point nearly the entire flow from the South-west District is received. The three overflows last named discharge directly into Taunton river. The overflow at Mill river can be availed of for flushing.

The overflow at the junction of Weir and Main streets is for the relief of the main sewer of any excess of water

coming from the eastern portion of the district, through Main street and Broadway. An old sewer now drains through Main and Weir streets to the river. I propose to remove that sewer, excepting the Weir-street portion of it, which is intended to serve as an outfall, from the overflow to the river. The new Main-street sewer is to be of larger size than the old one, and at their junction the grade line of the invert is to be so much the lower that the ordinary sewage flow will not enter the old drain, but pass down a vertical pipe into the main sewer draining the westerly portion of the district. But during a storm any excess of water coming down the Main-street sewer will rise into the old sewer and be discharged at the river.

Any excess of storm-water coming down the main sewer from the westerly portion of the district will escape at the overflows into the river.

But for the opportunity to turn river water freely into the main intercepting sewer, the grade of the lower portion of that sewer might be considered rather slight in comparison with its size, for efficient self-cleansing. With this excellent provision, however, no fear need be entertained but that an entirely satisfactory operation of the sewer will be secured.

The main sewer of the South-west District can be conveniently flushed by the brook water flowing near its location for a greater part of its length.

Overflows cannot be conveniently provided for this district as for the Central District, and as a considerable

portion of the area within this district is sparsely settled, I have relied upon keeping the rain water from unoccupied grounds in its natural courses and out of the sewers, to a large extent, so that the main sewer may be made smaller than would be otherwise practicable. Accordingly, I have, upon the plan, indicated sizes for the main sewer, giving about half the capacity allowed for sewers that must take and convey the whole of the storm-waters from an urban territory. This provision will be ample for a great many years; but when, in the future a further capacity is needed, plans suited to the requirements of the case can be executed at much less cost than to provide now for this distant want by constructing the sewer of large size. It still has nearly three and one-half times the capacity needed for a sewer which can be well relieved by overflows. As the work in the district is executed this condition of the plan in relation to surface water should be borne in mind and attended to.

MANUFACTURING REFUSE.

The sewers which have now been planned for the city provide for the discharge of all refuse, whether domestic or manufacturing, at a point below the Weir, except that from the area above the State Hospital grounds on the west side of the river and from Whittenton, Britanniaville and a small area opposite the Hospital grounds, on the east side of the river.

The refuse from this territory will be so diluted by the water of Mill river that I think no other provision need be made for it at present.

Should the discharge from manufacturing establishments, of an impure character, increase so much as to make a change necessary it will be practicable for each establishment to purify its own wastes to the needed extent before turning them into the river. But, eventually, it will probably become necessary to lay an intercepting sewer for this district. This is, however, so far in the future as not to need our present attention.

TOTAL LENGTHS AND COST.

The following table shows the aggregate lengths of the sewers of various sizes, included in the plan proposed, with an estimate of the average cost per foot for each size laid at the standard depth. The cost includes contractor's profit and the expense of engineering.

APPROXIMATE LENGTHS AND COST.

WEIR STREET DISTRICT.		OTHER DISTRICTS.	TOTAL LENGTHS.	ESTIMATED AVERAGE COST PER FOOT.
SIZE.	LENGTH.	LENGTH.		
12 in.	31,319	42,158	73,477	$1.70
15 "	12,165	12,516	24,681	2.23
18 "	8,269	12,235	20,504	2.55
20 "	3,979	4,380	8,359	2.77
22 "	1,661	1,940	3,601	3.03
24 "	2,340		2,340	3.31
38 "	590		590	6.60
45 "	1,060	290	1,350	7.80
48 "	,150	1,100	1,250	8.31
54 "	1,490		1,490	9.33
60 "	1,060		1,060	10.24
66 "	2,260		2,260	11.36
20 by 30 in.		840	840	3.35
22 by 33 "	691	2,539	3,230	3.70
24 by 36 "	2,798	2,543	5,341	3.98
26 by 39 "	1,720	3,886	5,606	4.37
28 by 42 "	4,789	408	5,197	4.68
30 by 45 "	2,550	3,030	5,580	4.95
36 by 54 "	2,200		2,200	7.47
38 by 57 "		650	650	7.95
40 by 60 "	150		150	8.45
44 by 66 "		1,570	1,570	9.19
48 by 66 "		1,990	1,990	9.78
54 by 60 "	2,350		2,350	9.89
60 by 66 "		2,530	2,530	10.73
Sums, feet	83,591	94,605	178,196	
Sums, miles	15.83	17.92	33.75	

To the size per foot, as given in the table, must be added the cost of man-holes and catch-basins. If these are made of the best materials and in the best manner, the average cost per foot of sewer will be about one dollar. There will be no great difference in the cost of appurtenances on account of the size of the sewer.

Some allowance has been made, in the estimate, for quicksand and water, but if these are met in great amount the cost will exceed these figures. It is my belief, however, that the execution of the work can be secured for rather less than the estimate, on account of the ground being more favorable than has been provided for. For the extra depths required on the main sewer of the Central District an allowance must be made, but this will not be of serious account. A small extra sum will also be required at each overflow, but I have made no detailed estimate as to this, for the reason that careful plans should be made when the work is ordered, and the estimates should be based upon them.

It will be many years before all the sewers included in this table will need to be constructed.

DESCRIPTION OF PLANS.

The accompanying large manuscript plan, covering the thickly settled portion of the city, defines, by a heavy, neutral-tinted line, the boundaries of the Central Drainage District, and by light neutral-tinted lines, the minor divisions, both within and without this district; it also shows the several sewers as proposed, their sizes and rates of fall, and heights above mean high tide, of their inside

Profile
of the
Proposed
CENTRAL MAIN SEWER
for the
City of Taunton.
Feb. 1878.
Scales:—
Horizontal, 400 feet to an inch.
Vertical , 20 " " " "
Shedd & Sawyer,
Civil Engineers,
Boston and Providence.
Proposed New Street.
Dean Cotton and Machine Co's Land.
Court St.
Weir St.
West Water St.
Washington St.
West City Sq.
Bank Row.
Little River.
High St. 30.65
Somerset Ave. and Dow St. 28.38
Summer St. 29.23
New Bedford & Taunton R.R. 28.40
White St.
Broad St. 14.36
Old Colony R.R. 16.53
First St.
Infirm'y St. 8.85
Second St. 7.12
Third St. 5.25
Fourth St. 3.51
Fifth St. 3.87
Shore Line.
Taunton River
High Water.
Low Water.
Storm Overflow
Storm-Overflow
Storm Overflow.
Base of Levels.
Inclination 1 in 85.
Inclination 1 in 300.
Inclination 1 in 140.
Inclination 1 in 500.
Inclination 1 in 2400.
2'0"×3'6"
3'9"cir.
4'cir.
2'2"cir.
2'×3'
3'2"cir.
4'6"cir.
4'6"×5'0"
5'0"cir.
5'6"cir.
11361.
10251.
9511.
9359.
7979.
7691.
7105
2347.
0.
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crowns, at various points; and contour lines, showing five-feet differences of elevation of the ground above mean high tide, as indicated by figures.

The drained territory so shown is about 1,600 acres in extent, for which about 33¾ miles of sewers are proposed

The printed plan contains the same information as the large one, excepting as to rates of fall of the sewers, and their depths, the limits of the Central District being defined by heavy dotted lines, and the minor divisions by light dotted lines.

The printed profile shows, in longitudinal section, the intercepting and main sewers, from Tremont street to the outfall at Taunton river, with the various sizes, inclinations and depths; and the storm overflow at the junction of Main and Weir streets. The figures above the profile indicate the heights of surface above mean high tide. Mean high and low tides are also shown, the ordinary range of which is 3.41 feet. It will be seen that high tide covers the invert of the sewer nearly as far up as Main street. This, however, is rather an advantage than otherwise; for it is a well-established fact that sewers are kept cleaner by the ebb and flow of the tides than where there is no such action. This profile, like all others of this class, is necessarily exaggerated as to dimensions, the disproportion between the vertical and horizontal scales being as 1 to 20.

CONCLUSION.

The study of this question has required more time than I anticipated. Many alternate schemes have been

considered and compared with each other, both as to general plan and as to detail, and I have confidence that the result which has now been arrived at will be satisfactory if the plan is faithfully followed.

The city is fortunate in being able to dispose of its sewage, in so simple and direct a manner, beyond its settled limits, without expensive outfall drains that serve no useful purpose as local sewers. There is no sewer included in our plan that may not serve for the attachment of private connections along its course.

Allow me to express my obligations for the patience and courtesy with which you have awaited the completion of my investigations.

Respectfully submitted,

J. HERBERT SHEDD, Engineer.

Providence, March 5, 1878.